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QUANTITATIVE EVALUATION OF ALTERNATIVE MILITARY COMPUTER ARCHIT--ETC(U)
APR 79 W B DIETZ DAA629-77-C-0034
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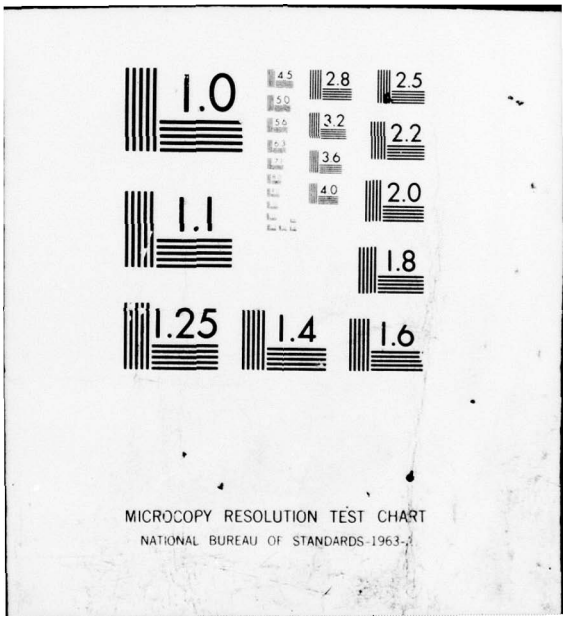
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides a summary of the quantitative evaluation of alternative military computer architectures. The problem studied under this effort was two pronged; 1) the development of techniques which would facilitate the quantitative comparison of computer architectures independantly of the way in which the architecture was implemented and 2) the development of methods for specifying computer architectures such that the original implementors are not needed to re-implement a compatible version of the architecture. A form was developed for the English language specifications and six of these specifications were developed.

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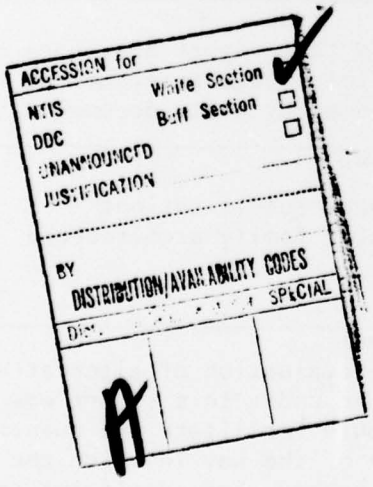
20. ABSTRACT CONTINUED

Their titles are listed in the publications section. These English specifications are to be used with the ISP descriptions to form as complete a specification as possible.



FINAL REPORT

ARO PROPOSAL NUMBER: P-15020-A-EL

TITLE OF PROPOSAL: Quantitative Evaluation of Alternative Military Computer Architectures

CONTRACT NUMBER: DAAG29-77-C-0034

NAME OF INSTITUTION: Department of Computer Science, Carnegie -Mellon University, Pittsburgh Pennsylvania

AUTHOR OF REPORT: William B. Dietz

Table of Contents

1. Problem Studied

The problem studied under this effort was two pronged; 1) the development of techniques which would facilitate the quantitative comparison of computer architectures independantly of the way in which the architecture was implemented and 2) the development of methods for specifying computer architectures such that the original implementors are not needed to re-implement a compatible version of the architecture.

1.1. Background

Traditionally, computers which are embeded in DoD data processing systems have been specified by the individual organizations responsible for the development of the system. The result has been that the large number of types of computers used in these systems are causing serious problems in the development and maintenance of software for these systems. In addition, the long development cycles (5 to 10 years) usually mean that the computers selected are obsolete before the system is fielded. The end result of these conditions is that the military pays over and over for development of computer systems that frequently fall short of performance expectations.

Since early 1975, the Center for Tactical Computer Sciences (CENTACS) of the U. S. Army Electronics Command has been supporting an effort to develop a family of military computers based upon a common instruction set architecture.

The fundamental premise of the MCF project is that software compatibility should be achieved by the adoption of an existing, proven computer architecture for the MCF, thereby minimizing the risks inherent in the design of a new computer architecture and permitting the "capture" of an existing and evolving software base. In this context, computer architecture is distinguished from implementation considerations, and is defined as the structure of a computer which a machine level programmer needs to know in order to write any time independent programs which will run correctly on the computer.

1.2. Comparative Evaluation

In order to narrow the field of candidates, a meaningful comparison procedure had to be developed and applied to the final candidates. This procedure yielded a quantitative set of results which were then used as part of a life cycle cost analysis.

1.3. Architecture Specification

In order to allow independent implementation of the MCF computer architectures, complete vendor-independent specifications of the computer architectures had to be made available to the implementors. In order to perform the evaluations of the computer architectures, a description of each architecture written in a computer description language was required. These descriptions constituted "software implementations" of the architecture because they could be used to drive a simulator which provided a running copy of each architecture. The ISP computer descriptive language and simulation facility were used. Due to the precise nature of these descriptions, they could serve the additional purpose of specifying the architecture of the candidate computers. However, due to the specialized nature of the ISP language, the descriptions are difficult to read for casual information. Therefore, a form for an English language specification was developed and an English specification for each of the MCF architectures was developed to augment the ISP description and form a more complete specification.

2. Results

2.1. Evaluation Results

Three life cycle cost studies have been carried out to provide data that would lead to the selection of a Computer Family Architecture (CFA) which could serve as the basis for a family of architecturally compatible computers spanning a wide range of performance levels. The first study was conducted under the direction of the Army/Navy CFA committee. After an initial screening, three commercial architectures (The DEC PDP-11, the IBM 360 and the Interdata 8/32) were compared and their relative life cycle costs were derived. The committee recommended the PDP-11 as the CFA. In the second study, the CFA "elect" was compared with four military computer architectures which are now used in a number of systems (the AN/UYK-7, the AN/GYK-12, the AN/UYK-19, and the AN/UYK-20). This third study compares the PDP-11 (designated the AN/UYK-41) with three architectures which are currently being developed for use in military systems (the DG Eclipse C/330, the AN/AYK-14 and the AN/AYK-15A).

The results of the three studies are displayed in Figures 1, 2, and 3. The numbers shown in each figure are relative to the average of the machines in that study. The log scale for the results is shown on the right of each figure and the linear scale is on the left. Since S, M, and R are measures of cost, a lower number is more desirable. The most efficient machines appear closest to the bottom of the figure. Thus, a machine with an S measure of .80 on the

linear scale will require only 80% of the memory used by the average of the machines tested.

The calculated confidence intervals were used to determine which machine effects were significantly different at the 95% confidence level. The dashed boxes in the figures enclose architectures whose performance differences were not significant at the 95% level. The size and placement of the boxes are such that if any other architecture's corresponding measure were to fall within the box, it too would be indistinguishable at this level of certainty.

Three of the architectures included in the third study are either similar or identical to architectures from the second study. Their relative performances, between the two studies, are consistent within the statistical accuracy of the experiment given the architectural differences involved.

2.2. Architecture Specification

A form was developed for the English language specifications and six of these specifications were developed. Their titles are listed in the publications section. These English specifications are to be used with the ISP descriptions to form as complete a specification as possible.

3. Publications

- Fuller, Samuel H. and William E. Burr, Measurement and Evaluation of Alternative Computer Architectures, Computer, Volume 10 Number 10, October 1977.

- Fuller, Samuel H., G. Mathew and L. Szewerenko, Phase II Comparative Evaluation of the MCF Computer Architectures, CORADCOM Research and Development Report # 79-9, Fort Monmouth, NJ, July 1978.

- Computer Family Architecture Selection, Phase III Final Report, Research and Development Report, Fort Monmouth, NJ.

- Dietz, William B., Evaluation of Alternative Computer Architectures; An Overview of Three Studies, Proceedings of the Second U.S. Army Software Symposium, October 1978.

- Dietz, William B. and Leland Szewerenko, Architectural Efficiency Measures: An Overview of Three Studies, Computer, spring 1979.

- Reid, Brian K., Scribe Introductory User's Manual, Carnegie-Mellon University, Computer Science Department, August 1978.

- Military Computer Family AN/UYK-7 Instruction Set Architecture Specification, Number EL-CG-2813-MCF, 7 July 1978

- Military Computer Family AN/GYK-12 Instruction Set Architecture Specification, Number EL-CG-2810-MCF, 11 July 1978

- Military Computer Family AN/AYK-14 Instruction Set Architecture Specification, Number EL-CG-2812-MCF, 25 January 1979

- Military Computer Family AN/AYK-15A Instruction Set Architecture Specification, Number EL-CG-2852-MCF, 10 July 1978

- Military Computer Family AN/UYK-19 Instruction Set Architecture Specification, Number EL-CG-2809-MCF, 24 October 1978

- Military Computer Family AN/UYK-41 Instruction Set Architecture Specification, Number EL-CG-2811-MCF, 20 October 1978

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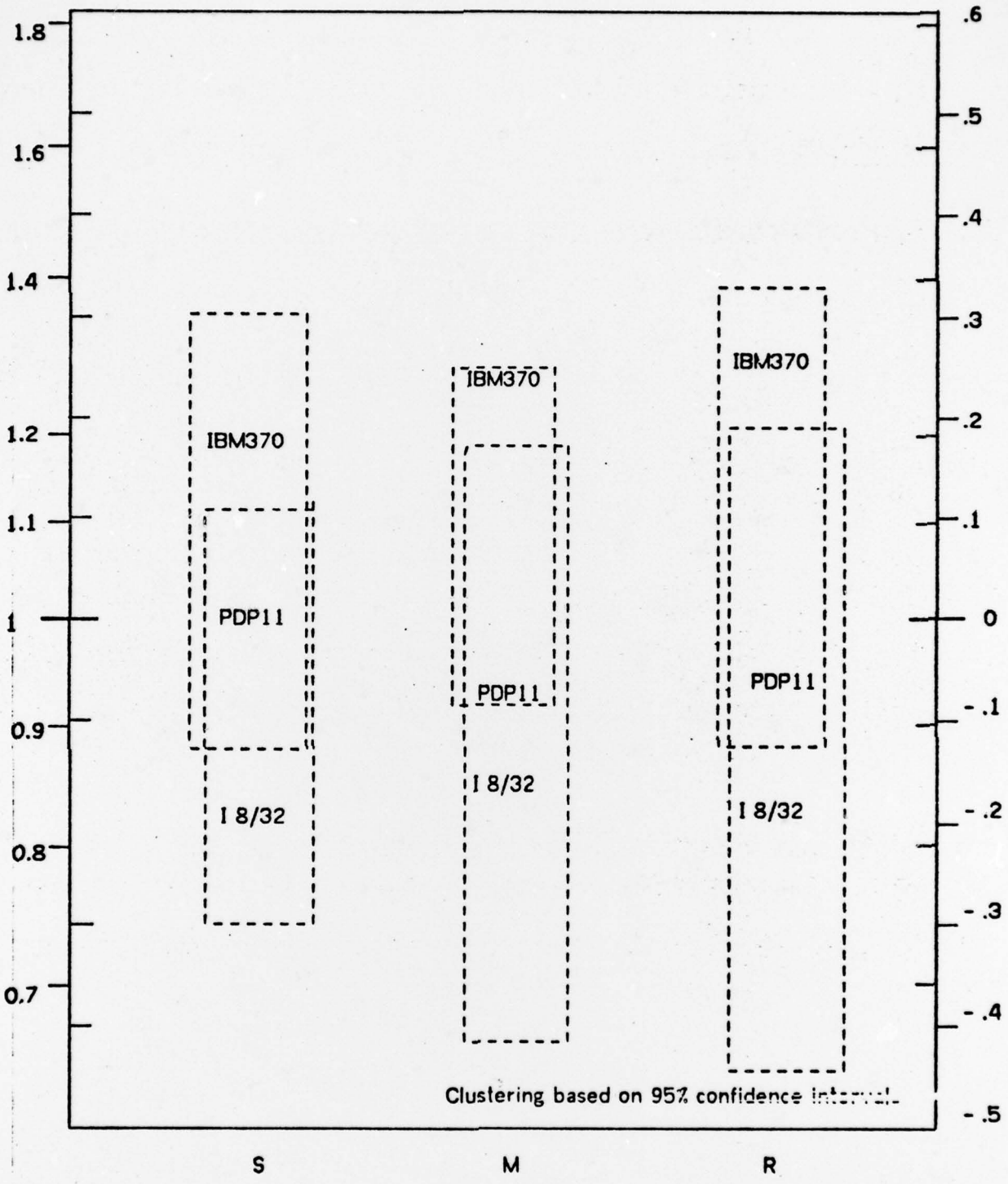

Figure 1: Composite Results for the First Study

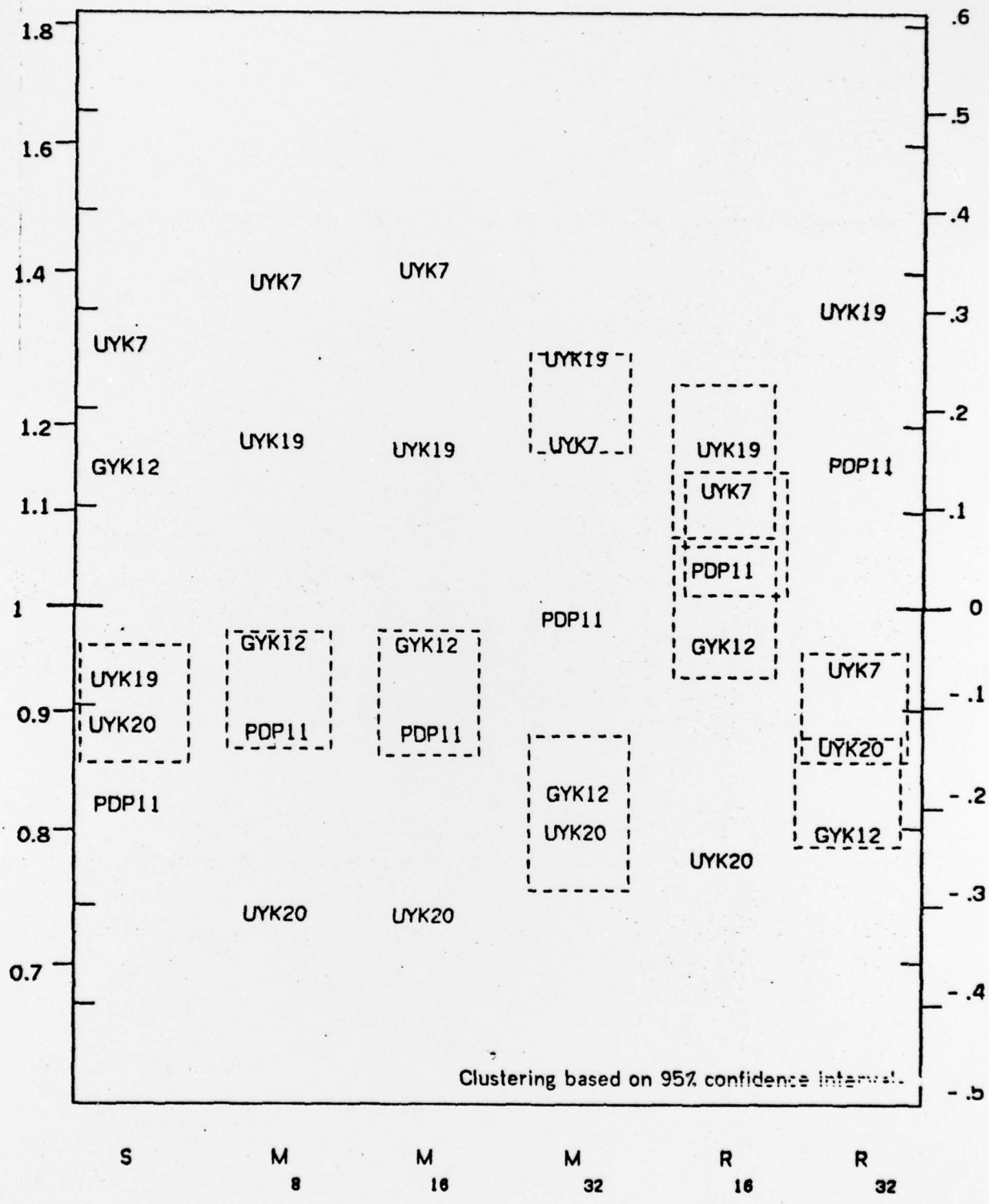

Figure 2: Results for the Second Study

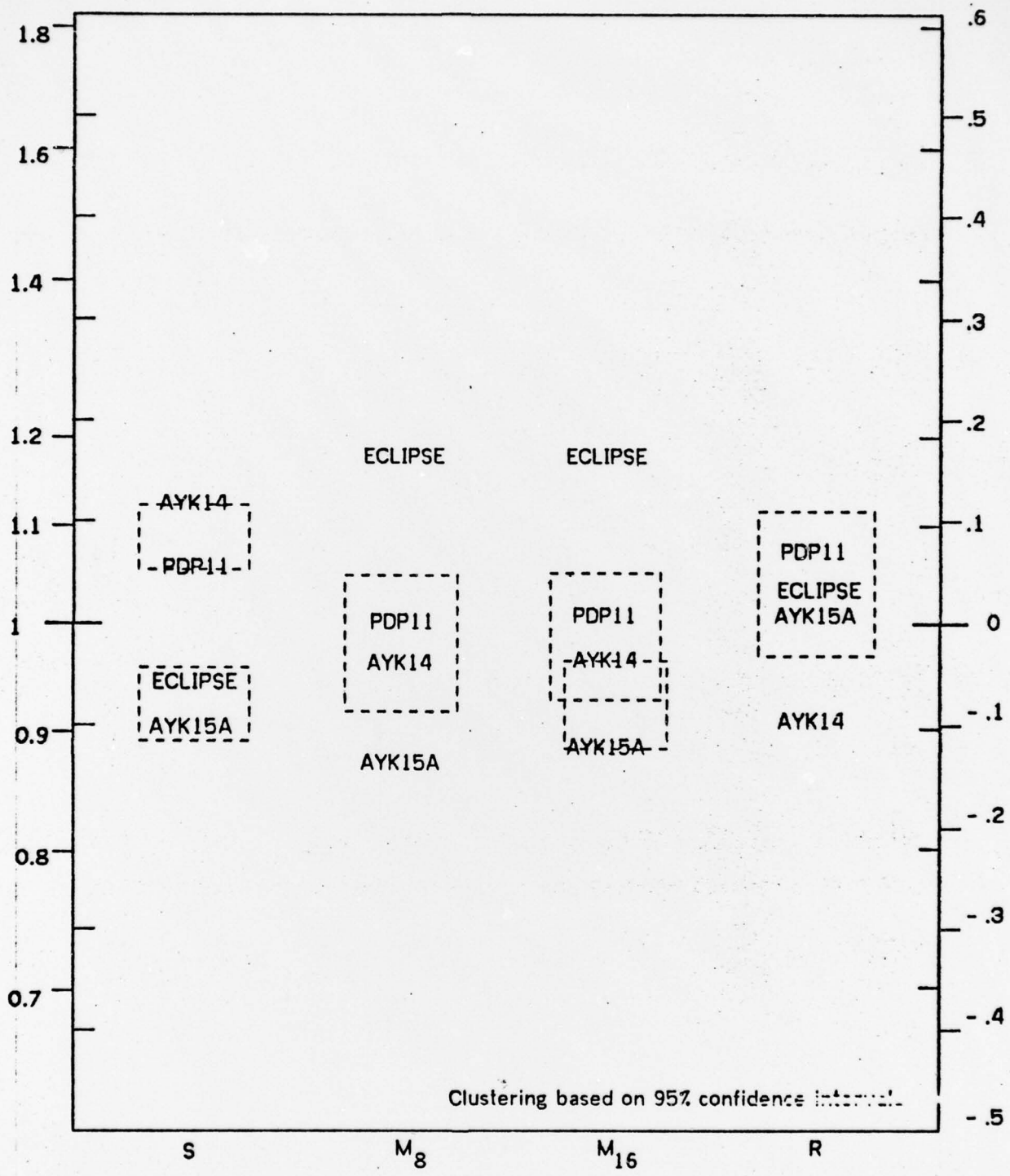

Figure 3: Results for the Third Study